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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Spiral-Groove Hydrodynamic Bearings

We N.V. PHILIPS' GLOEILAMPENFABRIEKEN, a limited liability Company, organized and established under the laws of the Kingdom of the Netherlands, of Emmasingel 29, Eindhoven, Holland. do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a spiral-groove hydrodynamic bearing.

Such bearings have a large bearing capacity and a very low frictional loss. For satisfactory operation of the bearing it is essential that the spiral grooves always urge a sufficient amount of lubricant into the gap between the bearing surfaces. Hence, lubricant must always be present at the outer ends of the spiral grooves. In the case of high speeds of revolution of the rotatable bearing member and when using grease as the lubricant, the possibility exists, that due to centrifugal force the lubricant does not reach the outer ends of the spiral grooves.

It is an object of the invention to eliminate this possibility.

According to the invention there is provided a spiral-groove hydrodynamic bearing comprising a rotatable bearing member and a stationary bearing member arranged one within the other and each having a first bearing surface extending in a plane at right-angles to the axis of rotation of the rotatable member and a second bearing surface adjoining the first bearing surface, the first bearing surfaces being arranged to co-operate with each other to support axial loads and the second bearing surfaces being arranged to co-operate with each other to support radial loads, wherein one of the first bearing surfaces is formed with an annular pattern of regularly-spaced shallow spiral grooves which, when the bearing is in operation, urge lubricant between the first bearing surfaces towards said axis, wherein one of the second bearing surfaces is formed, at least at an extremity thereof remote from the adjoining first bearing surface, with a first helical groove which, when the bearing is in operation, urges lubricant in an axial direction between the second bearing surfaces towards the spiral grooves, wherein the ends of the spiral grooves remote from said axis communicate through a duct in the stationary bearing member with the second bearing surfaces at a point located near said extremity of these surfaces, wherein the rotatable bearing member is formed with a storage space for lubricant, which space is bounded by a wall of the stationary bearing member, wherein a second helical groove is formed in a surface of the rotatable or stationary bearing member which is located between the storage space and the first bearing surfaces, which groove is arranged to transport lubricant from the storage space to the ends of the spiral grooves remote from said axis, and wherein a third helical groove is formed in a surface of the rotatable or stationary bearing member which is located to the side of the storage space remote from the first bearing surfaces, which groove serves as a seal to inhibit leakage of lubricant from the bearing.

By providing the storage space in the rotatable bearing member the lubricant, on rotation of this bearing member, is urged by centrifugal force to the wall of the stationary bearing member, where it comes within reach of the helical transport groove. This groove transports the lubricant to the outer ends of the spiral grooves so that these grooves are

always provided with sufficient lubricant to ensure a hydrodynamic lubricating effect.

According to one embodiment of the invention, the rotatable bearing member comprises a shaft formed with two spaced collars which are surrounded by a cylindrical internal wall of the stationary bearing member, the space between the collars forming the storage space, the first bearing surface of the rotatable bearing member being formed by a side surface of one of the collars, which surface is remote from the storage space, the second helical groove being formed in said cylindrical internal wall of the stationary bearing member or in a cylindrical peripheral surface of said one collar, and the third helical groove being formed in said cylindrical internal wall of the stationary bearing member or in a cylindrical peripheral surface of the other collar.

According to another embodiment of the invention, the rotatable bearing member comprises a sleeve having a portion of increased diameter, and the stationary bearing member comprises an annular member surrounding said sleeve and having internal surfaces which co-operate with external surfaces of the sleeve, the spiral grooves and all the helical grooves being formed in said external surfaces of the sleeve, and the storage space being formed in said sleeve portion of increased diameter.

In order that the invention may readily be carried into effect, two embodiments thereof will now be described by way of example with reference to the accompanying drawings, in which

fig. 1 is a sectional view of one embodiment of a bearing according to the invention;

fig. 2 is a similar view of a further embodiment; and

figs. 3 and 4 are an elevation and a sectional view respectively of a metal foil formed with spiral grooves.

The bearing shown in fig. 1 comprises a stationary bearing member 1 and a rotatable bearing member which is constituted partly by a shaft 2 arranged to be driven in one direction of rotation. The shaft 2 has a collar 3 the side surface 4 of which lies in a plane at right-angles to the axis of the shaft 2 and forms a bearing surface. The stationary bearing member 1 has a bearing surface 5 which lies in a plane at right-angles to the axis of the shaft 2 and which co-operates with the bearing surface 4 to support axial loads. In the bearing surface 5 is formed an annular pattern of regularly-spaced shallow spiral grooves 6 of known form which, on rotation of the shaft, operate in known manner to urge a lubricant between the surfaces towards the axis of the shaft 2. The shaft 2 further comprises a cylindrical bearing surface 7 which co-operates with a cylindrical bearing surface 8 in the stationary bearing member to support radial loads. In the bearing surface 8, at the end thereof remote from the bearing surface 5, helical grooves 9 are provided which have a pumping effect in an axial direction towards the spiral grooves 6 when the shaft is rotated. The discharge ends of the helical grooves 9 and the outer ends of the spiral grooves 6 communicate through ducts 10. An annular storage space 11 for lubricant is provided between the collar 3 and a second collar 12 on the shaft 2. The storage space is closed by a cylindrical internal wall 13 of the stationary bearing member 1. In the wall 13 are two sets of helical grooves 14 and 15 which both have a pumping effect in an axial direction towards the spiral grooves 6 when the shaft 2 is rotated. The grooves 14 serve as a seal to prevent lubricant leaking from the bearing.

The ducts 10 and the storage space 11 are filled with lubricant, for example, grease. When the shaft 2 is rotated the lubricant is urged by the spiral grooves 6 through the gap between the bearing surfaces 4 and 5 into the gap between the bearing surfaces 7 and 8. The lubricant is returned again to the outer ends of the spiral grooves 6 through the duct 10. The helical grooves 9 serve as a seal to prevent lubricant leaking from the bearing.

The bearing can support both axial and radial forces and has a hydrodynamic operation so that frictional losses are minimized. If the shaft 2 rotates at high speed it could happen that due to centrifugal effect, insufficient lubricant would reach the outer ends of the spiral grooves 6 with the result that the hydrodynamic lubricating effect is disturbed. To prevent this the lubricant in the storage space 11 is urged towards the wall 13 of the stationary bearing member 1 by centrifugal force when the shaft 2 is rotated. The helical grooves 15 transport the lubricant which is forced against the wall 13 by the centrifugal force to the outer ends of the spiral grooves 6 and thus keep the sealed lubricating system comprising the gaps between the co-operating bearing surfaces under pressure so that this system is always completely filled with lubricant. The transporting of lubricant by the grooves 15 only occurs when lubricant has been lost from the sealed system.

Although all the grooves in the embodiment shown in fig. 1 are formed in the stationary bearing member, alternatively all or some of the grooves may be formed in the rotatable bearing member without influencing the operation of the bearing. A variety of lubricants may be used but the bearing operates very satisfactorily with grease.

Fig. 2 shows a bearing which is constructed wholly as a separate unit from the shaft

and which may have the external proportions of a ball bearing. The rotatable bearing member in this embodiment consists of a sleeve 17 which is secured to a shaft 18 for rotation therewith. At one end the sleeve is formed with an enlarged portion 33 of increased diameter having a bearing surface 34 which extends in a plane at right-angles to the axis of the shaft 18 and in which is formed an annular pattern of spiral grooves 19. The sleeve 17 has a cylindrical bearing surface 35 in which are formed helical grooves 20. The stationary bearing member comprises an annular member 16 which surrounds the sleeve 17 and has flat and cylindrical bearing surfaces 36 and 37 respectively which co-operate with the bearing surfaces 34 and 35 respectively to support axial and radial loads. When the shaft 18 is rotated the spiral grooves 19 urge lubricant between the surfaces 34 and 36 towards the axis of the shaft and the helical grooves 20 urge lubricant in an axial direction between the surfaces 35 and 37 towards the spiral grooves 19. In contrast with the helical grooves 9 in fig. 1 the helical grooves 20 in this embodiment extend throughout the length of the cylindrical bearing surface. The part 20a of the grooves 20 serves as a seal to prevent leakage of lubricant from the bearing. The outer ends of the spiral grooves 18 communicate with the helical grooves 20 through ducts 21 at the region where the part 20a of the grooves 20 begins. An annular storage space 22 for lubricant is provided in the enlarged portion 33 of the sleeve 17. This portion is also formed with helical pumping grooves 23 and 24. The groove 24 transports lubricant, if required, from the storage space 22 to the outer ends of the spiral grooves 19 and groove 23 serves as a seal. The use of the sleeve 17 has the advantage that the grooves can be easily formed since they are all located in external surfaces of the sleeve.

The urging effect of the spiral grooves 19 and that of the helical grooves 20 are directed towards one another. The direction in which the lubricant circulates through the sealed lubricating system comprising the gaps between the co-operating bearing surfaces is determined by the stronger urging effect. The axial loads on the bearing are supported best if the urging effect of the helical grooves 20 is somewhat larger than the urging effect of the spiral grooves 19. For spiral grooves with a given urging effect, the pitch of the helical grooves 20 may be selected to give the grooves 20 the most suitable urging effect for a given ratio between the radial and axial loads to be supported. The transport groove 24 ensures that, if required, lubricant from the storage space 22 is added to the sealed lubricating system so that this system is always completely filled with lubricant.

The spiral grooves are preferably formed by an etching process in one side of a metal foil 25 which is shown in figs. 3 and 4. The metal foil is secured with its non-grooved side to one of the two bearing surfaces for supporting axial loads, for example, the bearing surface 5 in fig. 1. The forming of the grooves in a metal foil has the advantage of a simple manufacturing method which is suitable for the mass-production of the bearing.

WHAT WE CLAIM IS:—

1. A spiral-groove hydrodynamic bearing comprising a rotatable bearing member and a stationary bearing member arranged one within the other and each having a first bearing surface extending in a plane at right-angles to the axis of rotation of the rotatable member and a second bearing surface adjoining the first bearing surface, the first bearing surfaces being arranged to co-operate with each other to support axial loads and the second bearing surfaces being arranged to co-operate with each other to support radial loads, wherein one of the first bearing surfaces is formed with an annular pattern of regularly-spaced shallow spiral grooves which, when the bearing is in operation, urge lubricant between the first bearing surfaces towards said axis, wherein one of the second bearing surfaces is formed, at least at an extremity thereof remote from the adjoining first bearing surface, with a first helical groove which, when the bearing is in operation, urges lubricant in an axial direction between the second bearing surfaces towards the spiral grooves, wherein the ends of the spiral grooves remote from said axis communicate through a duct in the stationary bearing member with the second bearing surfaces at a point located near said extremity of these surfaces, wherein the rotatable bearing member is formed with a storage space for lubricant, which space is bounded by a wall of the stationary bearing member, wherein a second helical groove is formed in a surface of the rotatable or stationary bearing member which is located between the storage space and the first bearing surfaces, which groove is arranged to transport lubricant from the storage space to the ends of the spiral grooves remote from said axis, and wherein a third helical groove is formed in a surface of the rotatable or stationary bearing member which is located to the side of the storage space remote from the first bearing surfaces, which groove serves as a seal to inhibit leakage of lubricant from the bearing.

2. A bearing as claimed in Claim 1, wherein the rotatable bearing member comprises a shaft formed with two spaced collars which are surrounded by a cylindrical internal wall of the stationary bearing member, the space between the collars forming the storage space,

the first bearing surface of the rotatable bearing member being formed by a side surface of one of the collars, which surface is remote from the storage space, the second helical groove being formed in said cylindrical internal wall of the stationary bearing member or in a cylindrical peripheral surface of said one collar, and the third helical groove being formed in said cylindrical internal wall of the stationary bearing member or in a cylindrical peripheral surface of the other collar.

3. A bearing as claimed in Claim 1, wherein the rotatable bearing member comprises a sleeve having a portion of increased diameter, and wherein the stationary bearing member comprises an annular member surrounding said sleeve and having internal surfaces which co-operate with external surfaces of the sleeve, the spiral grooves and all the helical grooves being formed in said external surfaces of the sleeve, and the storage space being formed in said sleeve portion of increased diameter.

4. A spiral-groove hydrodynamic bearing substantially as herein described with reference to fig. 1 or 2 and figs. 3 and 4 of the accompanying drawings.

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